THE PRESENT STATUS OF EMPYEMA.

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In this communication only those cases of empyema thoracis will be considered which are caused by the common pyogenic organisms —streptococci, staphylococci, pneumococci, etc.—and which follow most frequently ordinary pulmonic inflammatory conditions. An entirely different problem is presented when the lesion is due to other inciting organisms, such as tubercle bacilli or actinomyces.

In 1915[11] some studies on empyema thoracis were completed and published. The conclusions which were brought out at that time have since been abundantly corroborated, and some of them seem to have acquired much additional significance. It is of importance to recapitulate the latter and to compare them with our added knowledge.

"In the vast majority of the cases empyema is secondary to some other inflammatory lesion in the body." Approximately 11 per cent. of the cases in the 1915 series were described as being "primary" in the pleura, and the most predominating reason for the assumption was that it was not possible to demonstrate at any time the primary lesion to which the pleural suppuration was subsidiary.

The opportunities afforded by postmortem* examination do not always lead to an accurate opinion concerning the mechanism of the early stages of the pleuritis. Except in those cases in which section of the lung demonstrates consolidated areas in anatomical relationship with the diseased area of the pleura, there are no criteria present upon which any judgment can be based. In the greatest number of the ordinary† cases of suppurative pleuritis the pathology, as demonstrated at autopsy, includes a localized intrapleural abscess of larger or smaller extent, bounded by thickened parietal and visceral pleural layers, on the pulmonary side of which the lung tissue shows no change from the normal, or only such superficial inflammatory, or compression, changes as would naturally be expected in a structure in direct and intimate anatomic relationship with a pyogenic process; these are the comparatively late cases. Such findings are expected in the primary pleuritis cases, but could equally well occur in the cases in which a pulmonary condition had antedated the pleuritis and in which, prior to the time the examination was made, healing of the lung lesion had been completed and had been accompanied with the disappearance of any perceptible evidence of the original anatomic changes; this state of affairs, I am quite sure, is very common.

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* No conclusive evidence can usually be demonstrated at operation regarding the priority of the lung or pleura in a pathological process in which both are implicated.

† The extraordinary conditions are, of course, those associated with epidemics. In a subsequent part of this communication the streptococcus cases which formed a fairly large proportion of the cases in the last influenza epidemic will be discussed. I have the impression that outbreaks of primary streptococcus pleuritides which affect relatively large numbers of people have been known unassociated with any "influenzal" epidemic.

Apparently a primary pleuritis can occur in one of two ways: One of the two, and perhaps the much less common, consists of an absorption of bacteria by the lymphadenoid tissue of the lung from the inspired air, with a consequent reaction in the pleura alone. Evidence toward this assumption was presented by Grawitz,[4] Arnold,[1] Heller[5] and Netter[8] in the period from 1890 to 1897, but since that time no additional proof of any kind has appeared in the literature. My own studies have led me to believe that under ordinary conditions this mechanism must be an exceedingly rare one, if it ever operates at all.

The second mechanism concerns itself with the phenomena associated with a temporary bacteremia. Organisms find their way into the blood stream, having gained an entry through the respiratory (including tonsils and adenoids), gastro-intestinal or genito-urinary tracts; and for some reason, which may not be apparent at any given moment, the pleura forms a fixation-point for the bacteria as these are filtered out of the circulating blood and an empyema results. Probably this mechanism functionates with many other similar or allied conditions; very possibly, too, it operates in the first of these two methods. Under such conditions it is very likely that the responsible organisms show an elective affinity for the pleural membrane. At the present writing it seems to me that no other available theory is adequate to explain the almost simultaneous occurrence of relatively enormous numbers of cases of primary pleuritis under epidemic conditions.

Over 90 per cent. of the empyemata one meets with are secondary to other immediately preceding conditions. It cannot be overemphasized how important this observation is. In this respect the term empyema holds an exactly parallel place with the term peritonitis: neither of these expressions conveys a total concept to the clinical mind unless it be immediately modified by an indication of the primary inciting condition. The primary conditions can be roughly grouped into (1) the meta- or postpneumonic empyemata; (2) those occurring by continuity from a neighboring perforating abscess, and among these abscesses of the lung take first place; and (3) the metastatic forms following a focus of suppuration at a distant point or taking the form of fixation abscesses in the course of established and continuing bacteremias.

1. The empyemata with which one meets most commonly are those following pneumonia. In children a form occurs in which both pleura and lung simultaneously become infected and involved. In adults this form is rare, and, as far as one can tell, the usual course of affairs includes a definite progression from a pulmonary inflammation to a pleural involvement. Rosenbach[13] was the first to suggest the probability that many of the meta- and postpneumonci empyemata are directly induced by the rupture into the pleural cavity of small superficially placed pulmonary abscesses resulting from foci of liquefaction in the consolidated portions of the lung. The difficulties in adequately settling this point, especially as to the frequency of its occurrence, are apparently insurmountable; but what evidence we have seems increasingly to show that this mechanism is perhaps the most common, if not the only one, by which the ordinary forms of meta- and postpneumonic empyemata make their appearance. In a number of instances I have been able to demonstrate these abscesses on the operating table. One of these was in a fresh case of empyema; the other was found during the course of operation for the closure of an old thoracic fistula: in both of these in exploring the visceral surface of the empyema cavity the finger was caught in a small round hole which led into the pulmonary parenchyma. The observation of Rosenbach[13] is also corroborated in the report of the U. S. Army Empyema Commission[3] in the cases which occurred at the camps during the epidemic, small abscesses, which often were multiple, were repeatedly found at autopsy in the lungs, gathered at their peripheries and directly under the visceral pleura.

These cases should not be conflicted with any of the forms of empyema in the second group—empyema cases complicating frank pulmonary abscesses.

Meta- and postpneumonic forms of empyema form about 69 per cent. of the total number of cases encountered.

2. About 2 per cent. of the empyema cases under ordinary circumstances complicate abscesses in the immediate neighborhood of the pleura. This group includes only those which are formed by direct extension or rupture of the suppurative process. Very few of these, indeed, are derived from the subdiaphragmatic space; the very largest number are derived from the rupture of pulmonary abscesses. The latter form an important group of empyemata. The mechanism in these cases is quite-simple, and it is possible to distinguish two varieties. In one of these there is a comparatively acute abscess formation with soft, non-demarcating walls, frequently multiple, commonly with few or no physical signs, and very liable to cause perforations between the non-adherent visceral and parietal pleuræ; the latter accident becomes associated with a sudden increase in the severity of the symptoms and the clinical picture becomes associated with, and characterized by, high fever, marked dyspnea

and cyanosis and other signs of a high grade of intoxication. The picture is that of a hyperacute pneumothorax. Pathologically these abscesses are noted by the absence of surrounding areas of induration. The resulting empyema involves, practically, the entire pleural cavity; the exudate is distinctly purulent, rather thin and frequently sanious, very foul and very toxic. As far as I know almost every case of this kind goes on to a fatal issue.

The second variety includes the chronic lung abscesses. The most characteristic of these are the foreign body intrapulmonary suppurations which follow aspiration of a fragment of tonsillar tissue during a tonsillectomy. Anatomically the lesion consists of a central cavity containing foul-smelling, brownish-red, grumous pus in which a multitude of organisms flourish; a limiting granulation membrane of firm consistence and a wide surrounding area of induration merging into pulmonary tissue in which fibrosis, secondary bronchiectatic dilatation and atrophy predominate. The lesion may be single or multiple and with it an advanced grade of suppurative bronchitis is associated. An adhesive pleuritis is almost the rule and is usually limited to the area of lung involvement. Empyema is less common; a general empyema is rare and occurs in those very exceptional cases in which no pleural adhesions have formed. The empyemata which are found are comparatively small and localized and the mechanism of their production becomes apparent from the anatomic structure in which one wall of the cavity is formed by much thickened parietal pleura and the opposing wall by suppurating membrane based on pulmonary parenchyma (pleural vomica). A bronchial fistula is always present. Clinically these are characterized by a prolonged period of illness, by a distressing cough, by fetid and profuse purulent sputum, by the evidences of progressive general deterioration and of local pulmonary involvement, and by characteristically definite roentgenographic pictures.

This type of empyema is illustrated by the notes of the following case:

In a man, aged fifty years, a lobectomy was done for a chronic lung abscess. The description of the pathology, as demonstrated at operation and by study of the specimen removed, is as follows: The lesion was present in the lower right lobe. The anterior, mesial and diaphragmatic surfaces of the lobe are free from adhesions. The latter are, however, present at the postero-internal border of the lung as far forward as the ligamentum latum pulmonum and for the entire extent of the latter from the pulmonary hilum to the base. In this location there is an empyema cavity containing several ounces of thick, yellow pus. The mesial wall of the abscess was a much thickened parietal pleura lining the reëntrant angle formed by the bend of the ribs and posterior mediastinum; the outer wall was pulmonary parenchyma in which the open ends of a number of bronchi of the second and third order were easily and distinctly visible. The empyema lay for the most part within pulmonary parenchyma.*

The demonstration of a bronchial fistula furnishes indubitable evidence of the presence of a suppurative process in the midst of the lung tissue. In the great majority of such cases the presence of the fistula is to be interpreted as proof of the priority of the pulmonary process, to which the empyema is subsidiary. In the lung-abscess-empyema cases the communication is frequently multiple, is usually direct and extends almost always into one or more fair-sized bronchi of the second or third order; the usually profuse and foul sputum, present before operation, resembles in all particulars the pus of the abscess; but it immediately disappears following the adequate drainage of the pulmonary abscess and reappears directly the drainage is interfered with from any accidental or purposeful cause. Healing is tedious and prolonged, and most often the bronchial fistula is an insurmountable obstacle to the closure of the thoracic sinus until, and perhaps even after, a radical operation is done. In those empyema cases which are subsidiary to the small superficial pneumonic abscesses (Rosenbach[13]) that rupture into the pleura a communication with the bronchial tree is not always demonstrable; in much the smallest number a communication makes itself apparent when, for one or another reason, a fluid irritating to the respiratory tract is introduced into the empyema cavity. The fistula may be tortuous and is narrow, and communicates usually with one of the smallest-sized or terminal bronchi. The amount of infiltration around the sinus tract is at a minimum, the tissues are soft and pliable and have a tendency to fall together; facilities for healing are most favorable in these cases, and it is exceptional for the communication to cause any extraordinary prolongation of the cicatrization of the wound. Characteristically the amount and physical appearances of the sputum is independent of the contents of the empyema cavity, has no resemblance to the wound discharges and depends for its production on any associated bronchitis which may be present or upon the liquefaction of the pneumonic exudate which had antedated the empyema.

In only a minority of the cases of empyema complicated with bronchial fistula is the evidence sufficient to indicate that the communicating sinus had resulted from the rupture of the empyema into some part of the bronchial tree. Such, for instance, would be so when an unrecognized liver abscess perforates through the diaphragm and discharges through a bronchus after having first created a subsidiary abscess in the intrapleural space; these occurrences, while quite well known, are relatively infrequent. With simple empyemata the discharge of pus into the respiratory tract is extremely rare, and probably when such an accident occurs it indicates the rupture of a coexisting, and perhaps unrecognized pulmonary focus. The experiences which I have had seem to show that the intrapleural abscess discharges much sooner on the skin (empyema necessitatis) or remains practically in an unchanged state except for the progressive thickening and even calcification of the limiting membrane. The prevalent beliefs in regard to accidents of this kind with simple empyemata seem to be exaggerations of the actual facts.

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* Private records.

I have, personally, seen only one case in which an empyema ruptured into a bronchus. This was a woman who was admitted into the hospital on the service of Dr. Libman. An empyema was demonstrated and the pus was removed by aspiration as a preliminary measure. Several days later the patient was transferred to the surgical side (Dr. Elsberg's service) for operation; her condition was excellent at that time. As the patient was put upon the table for operation she very suddenly began to show signs of pulmonary embarrassment and within a very few minutes there was a marked edema of the lungs; she was deeply cyanosed and complained of a choking feeling. Under vigorous stimulation she was tided over the emergency and within a few hours began to bring up in the sputum moderate amounts of pus demonstrating beyond question that the purulent focus had ruptured into a bronchus. I believe that a lung abscess was present which had, primarily, caused the empyema, and, secondarily, had ruptured into the bronchus; the presence of the lung abscess had been suspected from the clinical manifestations by the medical men before the transfer of the patient to the surgical side.

It is a different matter with the frank lung abscesses; perforation into the bronchial tree is almost the rule with partial, or complete, drainage of the pus in the sputum.

3. Metastatic empyemata are very common and comprise between 4 and 5 per cent. of the total number of cases ordinarily seen. It is very probable that the mechanism of their production is very intimately connected with the lodgment of infected emboli within the confines of the pleura derived from the original source of infection. It is less common for empyemata to complicate the bacteremias in which no localized focus can be demonstrated clinically; usually there preëxist foci of suppuration from which the bacteria-carrying emboli are derived. The same question arises with these cases as to whether the secondary process in the pleura is primary in the pleura or is in its turn subsidiary to a superficial lung abscess. It seems more rational to assume that the emboli lodge in the capillaries of the lung near the surface and, after liquefaction of the focus has occurred, the latter ruptures into the pleural cavity with the resultant empyema formation. The same difficulties in proving this point are present and in the few cases of this kind which I have had the opportunity of seeing postmortem the stage of the process

was so advanced as to make the elucidation of the question at issue impossible.

Metastatic empyema occurs most commonly after suppurative conditions in the lower abdomen and pelvis—postpartum sepsis, diseased adnexa, suppurative appendicitis; less frequently it follows thrombosed hemorrhoids, middle-ear suppurations or abscesses in other organs. In looking over my records I was surprised to see that I had never observed an empyema to follow a furunculosis.

Unless there is present an established bacteremia the prognosis for metastatic empyema is not any more grave than for other forms of suppurative pleuritis.

Conditions during the epidemic of 1918 and in the various army camps, although peculiar, fitted in with our previous knowledge. The empyemata seem to have followed one of several types.

1. The cases resembling those ordinarily seen and following pneumococcus pneumonias of the lobar type (Alabama drafts at Camp Custer and Camp Upton). The proportion of cases developing empyema was not out of the ordinary and in the Camp Upton cases (Brooks and Cecil[2]) it is put at 11 per cent. The trouble seemed to be that unexpectedly large numbers of the men came down with pneumonia; the pathological lesion itself or the complicating empyema showed no new phenomena.

2. In some of the camps (Camp Custer and Camp Sevier) there were large numbers of men who fell ill with measles. In such closely crowded quarters the measles assumed epidemic characteristics and an unexpected severity. That in turn large numbers of the men, ill with the exanthem, developed pneumonias of various kinds was to be expected; such a progression is common in civil practice when measles spreads in epidemic form in the wards of a hospital, and especially among adult patients. The clinical experience of the camp hospitals parallels that seen in the civil hospitals: the primary exanthem might be mild or severe; the complicating pneumonias were many, were either of the lobar or lobular type, were marked by the evidences of marked toxemia, were frequently complicated by empyema and the total mortality was very high.

In some of the measles cases at Camp Custer (Beals, Marlow and Zimmerman) the pleuritis occurred without any demonstrable preceding lung involvement. In a few of these lung infiltrations were found postmortem surrounding the intrapleural abscesses, but the physical characteristics of these and especially their distribution seemed to furnish sufficient proof of their secondary and subsidiary nature. Some of the cases of empyema following measles, which I studied in the 1915 series, were of this type.

At Camp Upton (Brooks and Cecil[2]) pneumonias frequently followed tonsillitis or other mild infections, and these, in turn, were complicated by considerable numbers of empyemata.

3. The most peculiar cases were those due to the "influenzal"

infection. The clinical pictures were characterized by a fulminating overwhelming of the patient by a tremendous toxemia and in the early stages of the epidemic this was so marked that large numbers of the patients died before any localizing process could form. Then, as the virulence of the epidemic abated somewhat, localizations were made out in the pleura more and more frequently; these assumed the characteristics of pleural effusions. The toxemia was still extraordinary and the patients died before the effusions could become definitely purulent. Very few empyemata were encountered in the early months of the epidemic for these very reasons. Toward the end of the epidemic empyemata began to appear: the virulence of the infection was at its lowest; the patients did not die so quickly; opportunity was afforded for the full development of the pathological process and the longer intervals were conducive to the slow transformation of a pleural effusion, heavily charged with organisms usually of the streptococcus group, into a frank pyothorax. The mortality was still high; the deaths occurred rather early and were due to the initial illness and the character of the infection with its marked toxemia.

Postmortem examinations were frequently disappointing. The pleuræ showed the lesions of fibrinous or serofibrinous pleurisy. The lungs showed patches of bronchopneumonia or the process involved an entire lobe. The bronchopneumonias of streptococcus origin were of a peculiar organizing type and were especially prone to undergo liquefaction and form abscesses (McCallum). Fairly often the lungs were free of any change. These last cases came nearest to the classification of primary pleuritis. Undoubtedly the infection in any case was blood-borne and temporary or more prolonged bacteremias existed to which the pleuræ, or pleuræ and lungs, were points of fixation.

The pleuritis cases of this group have very marked resemblances to similar cases which occurred in previous epidemics. I quote rather freely from Leichtenstern's monograph on "Influenza" in Nothnagel's *System*. "In previous epidemics there were numbers of severe, mostly fatal cases of acute primary 'grippe-pleuritis' which made their appearance almost simultaneously with the appearance of the epidemic. The clinical course began with chills; almost immediately thereafter there was a high, continuous fever, extreme dyspnea and marked cyanosis. In a very short time a rapid accumulation of pleural fluid took place which not infrequently was bilateral. The fluid was thin, turbid, seropurulent and of a yellowish color. In repeated postmortem examinations it was definitely proved that these were primary pleurisies without any coexisting inflammatory infiltration in the lungs. In the exudates streptococci were often found in pure culture. As the virulence of the infection subsided empyemata became frequent."

Exploratory Aspiration. In previous years this method of exploring the chest for fluid, or of substantiating the diagnosis of effusion, had reserved for itself a paramount place. In spite of the fact that certain dangers attend its use, aspiration is of such value as to make one disregard them; and, to be sure, these occur very rarely, especially those which lead to untoward results. The most unfortunate of the latter is the occurrence of sudden death. The explanation of these reflex phenomena is most obscure.

As the cases present themselves it is found that the needle is most successful with the larger empyemata, especially those in which more or less total collapse of the lung has occurred. The procedure is, however, most valuable in the cases of localized collections of pus, since the physical signs are frequently inconclusive, both as to the presence and topography of the abscess cavity, while the clinical course strongly suggests the presence of a pus focus within the thorax. This is particularly so in the localized empyemata restricted to the upper areas of the chest, both in front and in the axilla, or in those confined within the borders of the pulmonary fissures. Particularly baffling are those within the axilla: it frequently happens that aspiration is practised in the usual areas, posteriorly, corresponding to the midscapular line, and in several different interspaces with negative results, while a little farther outward, toward or within, the axillary confines, purulent fluid would be produced. In actual practice it is always advisable to insert the needle in the very center of the area thought to contain fluid; toward the outer borders of the latter the layer of fluid may be thin and the needle is very apt to penetrate entirely through the fluid-containing space and to project beyond into the lung parenchyma, of course with negative results. One is frequently chagrined when, after having a great deal of difficulty in locating the pus with the needle, and after finally locating what is seemingly a small collection at some unusual and not easily accessible point, one discovers at operation that the empyema is of very large proportions thoroughly ample to cover and include every one of the aspiration areas. The reason for this difficulty is obvious from the foregoing statement.

A number of other sources of error are present in the practice of aspiration. In a number of the cases several loculi of fluid are present in the chest, and while one or several of these contain purulent exudate, another or others contain serous-like fluid (mantelergüsse of König); whenever pus is strongly suspected and clear fluid is withdrawn it is advisable to repeat the procedure at a different point in order to make absolutely sure that this snare is avoided.

In other cases the source of error lies in the withdrawal of pus when no empyema exists. On a number of occasions on the medical side of the hospital, and especially in children, the stage of resolution of a pneumonia was accompanied with symptoms resembling very strongly those associated with purulent foci; aspiration having been practised purulent fluid was withdrawn. When transferred to the surgical side for operation the use of the needle failed to substantiate the presence of fluid of any kind* and further observation was followed by complete defervescence and spontaneous cure. It is quite likely that in these cases the needle entered a large bronchus and withdrew some of the bronchial secretion, or possibly some of the liquefied pulmonary exudate was sucked up into the syringe.

Very difficult of distinction are the purulent collections in intimate relation with the diaphragm, and with the needle alone it is frequently very difficult, if not impossible, to decide definitely whether the pus is situated in the pleural cavity or in the subdiaphragmatic space.

Roentgen Ray. Much more accurate work can, however, be done with the roentgen ray. The diagnosis of fluid can be accurately made in the largest percentage of the cases examined. In those with collapse of the lung the roentgenographic shadow is usually diffuse and covers either the entire side of the chest or its lower half or two-thirds; in these the advantage of the roentgen ray over the exploring needle is not so obvious as in those about to be described, inasmuch as it is extremely improbable for one to miss the fluid in aspirating. The superiority of the roentgen ray over the exploring needle is, however, pronounced in all cases of localized empyemata whether the cavity be relatively small and obscurely placed or whether it be limited to one of the aspects of the thoracic wall. In the former the feasibility of reaching the cavity with the needle is at a minimum and very often it is merely a matter of luck whether one succeeds in entering the cavity at all; the roentgen ray, however, gives an accurate picture of the size, the location and the relative anatomic relationships of the pus cavity, and reaching the latter with needle or incision is then a matter of comparative ease and of almost mathematical precision; stereoscopic plates are invaluable and very essential for this purpose. In the larger localized empyemata the same advantages are still present though not to such an extreme degree; much useless aspiration is, however, avoided. The manifest superiority of the roentgen ray is illustrated in the notes of the following case:

A young man had gone through a severe lobar pneumonia, and having passed the critical stage was apparently on the road to complete recovery. Fever, however, recurred and with a progressive deterioration in the general condition, a continuing loss of weight and a persistent cough, it was strongly suspected that pus was present somewhere in the chest. Repeated aspirations were negative until finally the pus was located in the axillary space by the medical consultant. A roentgen-ray picture had been taken but had not been properly interpreted. When I came to operate upon the patient I was able to point out the location and boundaries of the empyema cavity in the roentgenogram and to show that with proper interpretation the pus could have been reached on the first aspiration.*

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* In a case of this kind the roentgen ray would be of tremendous help.

The delimitation of the empyema cavity by roentgenographic study has been of particular help in establishing beforehand the most advantageous point for drainage; the site of the incision can then be accurately planned. The notes of the following case are instructive:

A boy, aged eighteen years, had been operated upon for a post-pneumonic empyema. There had been a great deal of trouble in finding the pus with the needle, but, finally, it had been located in the lower part of the right chest very far forward. The incision, which was made, corresponded to about the level of the sixth rib and was entirely in front of the anterior axillary line. Operation was, however, followed by a continuance of the fever. When I came to see the patient I was shown the roentgenograms and, even before examining the patient, I was able to point out clearly the entire boundary of the empyema cavity, to show that the pus had been reached at the most anterior and inferior part of its extent and that the entire cavity lay behind the line of incision. As the patient lay on his back in bed the drainage opening was at the topmost extremity of the cavity; retention was, of course, present, accounted for the persistence of the fever, and necessitated a second incision posteriorly, the planning of which could be accurately done before operation from the roentgenographic pictures. All of this could have been avoided by correct reading of the plates originally.*

The use of the roentgen ray affords another advantage in that frequently other unsuspected lesions are demonstrated in the picture. Perhaps the most important of these are the presence of associated pneumonic foci in the same or opposite lung. The question of whether a general anesthetic can be safely employed or whether one must have recourse to local anesthesia can then be decided much more easily and on definite criteria. The physical signs of such "silent" patches are indefinite and inconclusive and are not prominent enough to attract one's attention while examining the chest; frequently these small patches give no physical signs at all; they are, however, usually easily demonstrable in the roentgenographic pictures. A similar observation was made by Whipple several years ago; writing from the Presbyterian Hospital he pointed out how commonly postoperative pneumonias would go unrecognized because of the absence of any conclusive physical signs, if it were not for the roentgen-ray evidence. In my earlier experiences I remember several occasions when the thoracotomy was very promptly followed by an exacerbation of symptoms manifestly due to an area of pulmonary consolidation; undoubtedly this had found its origin in an unrecognized, silent and perhaps defervescing patch which had been stirred up into renewed activity or had been effectually spread by the irritating anesthesia.

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* Private records.

In exceptional cases the etiology of an unexplained empyema is clarified by the roentgen-ray studies. A very interesting case is the following:

In a man of fifty years the predominating symptoms were a continued fever and a productive cough. Repeated exploratory aspirations of the chest were negative until finally some clear fluid was withdrawn; later a thoracotomy was done. An abscess was reached presumably in the midst of the lung and drainage was instituted; the discharge from the wound resembled the purulent sputum. Drainage continued unchanged for months. Roentgenographic pictures were repeatedly made, but had not succeeded in clearing up the underlying condition. Finally in one plate a gap was noted in the dorsal part of the third rib near its bend and angle which the radiographer interpreted as a new growth. Subsequent plates showed the defect to be increasing in size. The interpretation of the clinical picture was now easily made; the man had a tumor of the lung; this had involved the pleura, induced an effusion and the latter had become infected; the rib was the site of a metastatic growth or had become involved by direct extension of the tumor.*

Treatment. The treatment of empyema is not difficult in theory but extremely difficult in practise. It involves principles established for many years. Necessarily it divides itself into that before operation, during operation and after operation.

Every empyema that one sees has gone through a stage in which the exudate was a relatively clear fluid, which, as time goes on, shows a progressive turbidity and passes finally into the stage in which the exudate is frankly purulent. As a general rule the fluid is heavily charged with bacteria and the abundance of the latter varies inversely with the length of time since the onset of the effusion; the longer the fluid remains in the chest the greater tendency there is for the bacteria either to disappear or to lose in virulence.

During the recent epidemic it rapidly became apparent that whenever the cases were operated upon very early—and this usually meant as soon as fluid accumulated in the chest—an appalling mortality resulted. Later it was learned that a policy of abstention from operation in the early periods of the pleural effusions was followed by vastly better results and that the proper time for operation only came later when the exudate was distinctly purulent, when the initial toxemia had abated or had been overcome, and perhaps when the original pneumonia had disappeared. All of these facts are not peculiar to the epidemic; they are equally true of the ordinary cases. In the communication made in 1915 this condition of affairs was dwelt upon and it was pointed out how the mortality seemingly became lower and lower the longer the pus was retained in the chest. The ambiguity of the situation was also pointed out at that time, inasmuch as notoriously bad results are obtained whenever the condition is neglected and the purulent collection is undisturbed for extraordinary lengths of time; the moment for operation comes only some time after the appearance of the intrapleural process and permits of no excessive delay; the timeliness of the surgical interference is easily apparent to the clinician. A similar observation had been previously noted by Werner and the superiority of comparatively late over early operation has also received the confirmation of the Empyema Commission.

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* I am indebted to Dr. Elsberg for these notes.

It is not definitely settled just why the initial period of a suppurative pleurisy should carry with it agencies which contribute an excessive danger to an open drainage of the chest. A number of factors seem to be present: (1) The dangers of an open pneumothorax associated, perhaps, with the spread of the infectious process to other uninvolved portions of the pleura; (2) the risks of a further compromise of lung tissue leading to a dissipation of the respiratory function until the normal reserve is exhausted to the danger-point; (3) the absence of adhesions and the failure to fixate adequately the mediastinum so that "flapping" takes place; (4) the excessive toxicity of the exudate, the increased facility afforded by operation for absorption and the inadequate preparation of the human organism in the matter of necessary antibodies to overcome the toxemia; (5) the presence of the primary illness, especially a pneumonia, still in an active state; (6) and, lastly, and perhaps most important, and perhaps the only reason, the added insult of any operative procedure—especially one resulting in an open pneumothorax—with its unavoidable shock to a patient whose resistance, because of all things considered, is at an extremely low, if not at the lowest, level. In any individual case the correlation of all of these factors working at the same time, or the operation of any one, or any group, of them is not only possible, but extremely probable if surgical interference is undertaken at an inopportune time.

During the epidemic these facts were emphasized much more strongly than would ordinarily be possible. Preliminary aspiration of the chest as a therapeutic measure has therefore grown in favor, and it has been found advisable to repeat the evacuation of the fluid as often as the general and local signs of the patient make the indication. The chest is best emptied with some form of suction apparatus—a Potain apparatus is excellent—and as much fluid as is possible should be withdrawn; a large caliber needle facilitates matters very much. The evacuation of the fluid is usually promptly followed by an improvement in the pulse and general appearance of the patient. Within a few hours there is an appreciable drop in temperature; in many the normal level is reached. As the fluid reaccumulates the temperature rises again; sometimes the interval between aspirations may extend to several days. A recrudescence of fever is a very good guide for the repetition of the procedure.

Repeated aspirations are usually followed by rapid improvement in the general condition of the patient. This may cause difficulty in giving the patient an unwarranted sense of cure from the purely temporizing measure; in several patients operation was, therefore, refused at the proper moment, and permission to do so was only obtained at a comparatively late interval, when the initial benefits derived from the aspirations were replaced by other disadvantages, due to the extraordinary time the pus was allowed to remain in the chest; in one of these patients return to the hospital and operation was only acceded to after the empyema had perforated through the chest wall. It is well, therefore, to explain primarily to the patient, or to the latter's family, that the aspiration is only a temporary measure and that operation is being postponed for the sake of the added safety which the temporizing measure affords.

Preliminary aspiration has been found very satisfactory for tiding the patient over the dangerous intervals until the establishment of an open drainage of the chest is fairly safe. The criteria for determining the latter point are rather crude and include the physical appearances of the exudate; the general objective signs—temperature, pulse, etc.—pointing to a diminution of the initial toxemia; and improvement in the physical signs indicating, as far as one can tell, an appreciable resolution or disappearance of the pneumonia when the latter is the primary illness. Operation should not be done until the fluid is very purulent and until the toxemia has completely disappeared.

Very rarely repeated aspirations result in a disappearance of the exudative process and an actual cure. In my own experience this has occurred only in very young children and infants. In actual practice such a small assurance of permanent cure is offered by this method as to make the possibility negligible.

The question of whether or not infection can be spread during operation to healthy portions of the pleura is very important from the surgical point of view. As one sees the cases of empyema in the hospital they fall readily into one of a number of groups.

1. The empyema is a localized abscess and, compared with the total size of the interior of one side of the thorax, is relatively small. The abscess is well walled off, the adhesions are fairly strong and manipulations must be accompanied with the exhibition of considerable force before these will rupture. If the condition has existed for a considerable length of time—several weeks—the adhe-

sions are very firm indeed, much firmer than any adhesion ever seen in the abdominal cavity, and even at postmortem examinations it is next to impossible to tear these apart; almost always the pulmonary parenchyma ruptures before the scar tissue in the pleura gives way.

2. In the second group the lobes of the lung on the affected side have collapsed and have become fixed in place in a more or less shrivelled state in the interval formed by the curvature of the ribs and close to the spinal column. The degree to which the lungs have collapsed may be extreme or may be at a minimum; in the former the thoracic cage is practically in its entirety an abscess cavity; in the latter the cavity is rather shallow, although it extends from the upper to the lower limits of the thorax and is most frequently in relation with the axillary portion of the chest wall. In between these two extremes all grades can occur. In the extreme cases practically the entire extent of the pleura, both visceral and parietal, is compromised in the infectious process and no further extension can conceivably take place. In the others the differentiation from the cases in the first group is one only of relative size. Here, too, the character of the adhesions present is exactly similar, and, while when the condition is still fresh they may give fairly readily to the finger, as time goes on, they acquire more and more a cartilaginous consistence and the use of scissors and scalpel are required before the parts can be separated.

On a number of occasions while operating upon children and when conditions similar to those described were present, I have purposely broken through the limiting adhesions bluntly with the finger and have liberated the lobes of the lung as far as I could reach. It was easy in the children to reach as high as the apices of the upper lobes and widely from side to side. Comparatively large areas of uninfected and uninvolved portions of the parietal and visceral pleura were bared to the infection; yet the clinical course after operation gave no indication either in temperature, pulse or other objective or subjective symptom that the pathological process had been increased in extent.

3. The third group includes the cases of empyema associated with lung abscess for which radical operations (lobectomy) are done. Under such conditions the actual proof of the spread of intrapleural infection during operation has been given to me on one occasion, but I do not believe this experience to be unique.

This was a man with a pulmonary abscess fairly well localized in the upper right lobe. A lobectomy was done while the rest of the pleura was guarded from infection by appropriate means. At the conclusion of the operation the resultant cavity was lightly packed with iodoform gauze; in addition a counteropening was made into the costophrenic sinus and a tube was led in through this opening and brought up to the level of the uppermost portion of the thorax near to the stump of the upper lobe. The man died some ten days later. The postmortem examination showed marked infection of the cavity resulting from the extirpation and an abscess between the under surface of the lower lobe and the upper surface of the diaphragm which did not communicate with the drainage tract. The intervening portions of the thorax were apparently clear, though, to be sure, the visceral and parietal pleuræ were adherent throughout with the exception of that part occupied by the tube (drainage tract).*

Cases of this kind are really primary operative infections of the pleural cavity and resemble very much infection of the peritoneum during a laparotomy with residual abscess formation.

The assumption seems justifiable, therefore, that in the ordinary case of empyema the danger of spreading the infectious process by open thoracotomy is relatively small. In truth the present custom of operating does not permit of any spread of infection. The extent and boundaries of the empyema cavity are accurately delimited prior to operation by adequate roentgen-ray examinations, so that the most favorable point for drainage can be definitely established beforehand. The operation, and this, of course, refers to the early cases and to primary operations carried out at the most opportune time, becomes then merely an incision into an abscess (empyema) cavity and the institution of proper drainage; such a procedure carries a minimum of danger of spreading the infection. In the very exceptional case in which for one or another reason it is deemed advisable at the primary operation to part the adhesions in order to liberate the lobes of the lung, the experience detailed seems to show that little need be feared of the danger of spreading the infectious process to hitherto uninvolved surfaces in all but the lung abscess cases.

Perhaps in some of the cases which have come under my observation some spread of infection has occurred, but having given no perceptible evidence it was unrecognizable in the general clinical picture with the means at our command. Such an occurrence is wholly compatible with the statement made immediately preceding. The character of the infecting organism and the intensity of its virulence as compared with the resisting powers of the patient would have most important bearings on this phase. In several children, in whom the presence of no adhesions and the involvement of the total parietal and visceral surfaces of the pleura indicated that the process most probably followed the rupture of a small superficial focus of liquefaction in a pneumonic lobe, (Rosenbach) a thorough consideration of the history and the clinical course failed to show that any extraordinary symptom had marked the onset of the pleuritis and its conversion into an empyema. On the other hand the phenomena accompanying the rupture of an acute pulmonary abscess into the pleural space is marked by an extreme increase in the clinical symptoms, and especially in the toxemia. The manifestations of an operative infection of the pleura, as, for instance, that following a lobectomy for a chronic lung abscess, are not so prominent and are probably much mitigated by the immediate institution of ample drainage.

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* Case from surgical service, Mt. Siani Hospital.

Methods of drainage of the chest, now as formerly, are essentially one of two—intercostal incision* and rib resection. Intercostal incision is the older operation. Many years ago it was the operation universally employed; but there was much difficulty with the after-treatment, especially from the point of view of securing adequate drainage, and gradually the method was abandoned and replaced by rib resection. In the series which I studied and reported in 1915, 21 of the patients (total number 299) were operated upon by intercostal incision. These were the desperately sick cases, and the operation was done as a matter of expediency rather than as a matter of choice. The important point that was brought out was that there never was any trouble in securing adequate drainage; the healing of the wounds was not only not impeded but actually hastened. Since that time my experiences have only served to substantiate this viewpoint, and I have done intercostal incision practically to the exclusion of other methods. At the present time there seems to be little doubt that from the mechanical point of view intercostal incision and rib resection are equal for drainage purposes, and if intercostal incision is otherwise satisfactory for desperately sick patients, I can see no reason why it should not be equally efficient for the ordinary cases. I have had no cause to regret this attitude, and since the outbreak of the first epidemic of influenza and since the occurrence of the large numbers of pneumonias, with their consequent empyemata, in the various army camps, this opinion seems to be confirmed by the increased favor with which intercostal incision is being regarded throughout the country.

It is difficult to understand why the opinion should have become prevalent that intercostal incision does not yield a drainage equal to that obtained by rib resection. By using one or several appropriately sized tubes and making the incision between the ribs long enough a comparatively large opening is very readily obtained both in children and in adults. As a matter of fact the actual opening leading into the thorax, when rib resection is done, is very seldom any larger than that obtained with intercostal incision; it is only the outer wound, perhaps, which is larger and that is inconsequential. When the tube, or tubes, are properly placed there are no impedimenta to the outflow of the thoracic contents; drainage is perfect and no retention of pus can be demonstrated. I have frequently seen retention and fever after thoracotomy for empyema, but just as often this was present in cases which had had a rib resection done as in those with intercostal incisions, and I feel quite sure that many other men have had similar experiences.

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* Continuous drainage through an intercostal opening made with an ordinary trocar is after all nothing but an intercostal incision. In children and infants it may be all that is needed; in adults the opening obtained is much too small for efficient work especially when one wishes to make use of irrigations with an antiseptic solution. When combined with suction it is, of course, the old Bulau method of treating empyema.

Except for some special purpose I have abandoned rib resection, and as time goes on the exceptions to the rule and the special reasons are growing less. There are two very valid objections to rib resection as I see the problem since an equally efficient drainage can be accomplished with intercostal incision.

The usual method of doing rib resection is practically an enucleation of a segment of rib from its periosteal covering. When done in that way much newly formed bone is thrown out from the osteogenetic layers, and because the latter lies on the inner side and circumscribes the drainage tract the new bone is crowded in between the adjoining ribs; commonly it becomes superabundant; large plates of bone then form which cause mechanical hindrances to the normal respiratory excursions of the chest wall. The sinus itself becomes surrounded by a bony wall which, more frequently than is apparently recognized, forms an obstacle to the proper closure of the sinus. Both of these form prolific sources for the formation of chronic empyema sinuses and for repeated operations. Both of these undesirable phases can be obviated by excising the rib *in toto* after the suggestion of Lilienthal.

A solution of continuity of the rib opens up surfaces of bone tissue to infecting agencies. In the previous communication (1915) I was under the impression that this was immaterial and that the rib was able to avoid, or quickly overcome, any infectious process to which the environment might lay it open. I have since been disillusioned. Fairly frequently the rib becomes infected, an osteomyelitis affects the rib for a variable distance from the cut surface and healing is prolonged until the dead bone is cast off or until a similar result is obtained by operation. The process may also involve any part of the new bone formation which is thrown out around the drainage tract. When the segment removed is in the immediate neighborhood of the costal cartilages the probabilities are strong that the cartilage, too, will become infected; this would be a rather serious complication. In a communication relating to the infections of the cartilages, Moschcowitz[7] pointed out that an infected cartilage never heals spontaneously, and only heals after operation when every bit of it is removed down to healthy portions of the bone to which the cartilage is attached. In the connecting segments of the cartilages this would entail an extensive secondary operation before closure of the sinus results.

All of these troubles can be very nearly avoided by making the intercostal incision. Occasionally when a tube too large for the intercostal space is employed, pressure necrosis of the soft parts overlying the rib results in a superficial baring of the bone; the latter does not compare, however, with the osteomyelitic process set up in a resected rib.

A very important advantage of intercostal incision is that the operation can be very easily done in bed. With a very sick and toxic patient, or in one with a badly compromised circulation, the transportation of the patient to and from the operating room is a very serious item. I am quite sure that several of the fatalities which I have seen have been due to this cause. The simplicity of intercostal incision, as compared with rib resection, is extreme.

I believe that it is important not to make the drainage opening in the chest wall of larger caliber than the diameter of the main bronchus entering the lung. Expansion of the lung is a very necessary factor in the contraction of the empyema cavity, and it is only accomplished by the current of air entering and distending the interior of the lung. Ordinarily this has no opposing force. With a fistula in the thoracic wall a current of air is sucked into the empyema cavity with each inspiration, and if its volume is larger than that entering the normal channel, no distention of the lung substance occurs.

The simplest form of drainage apparatus—an ordinary rubber tube—is the best. It is usually taught that it is sufficient for the tube to project just within the inner surface of the thoracic wall in order to obtain complete drainage. Theoretically this should be so; practically it is very frequently not so, especially with the larger cavities, and drainage is not efficient. It is found to be better practice to allow the tube to project into the thorax for a little way and to shorten it progressively as the empyema cavity shows signs of contracting. Various forms, of drainage apparatus, with and without valve formations, and manufactured of various materials, have been proposed and employed, and each is said to have some special advantage; but none of these can compete in flexibility of application with the ordinary rubber tube.

In the last two or three years the addition of a suction apparatus in the after-treatment for the purpose of aiding the constant evacuation of the chest has become very popular. The method is a very valuable adjunct to the treatment of empyema. It is most comfortable for the patient; it eliminates many dressings; it reduces the bulk of the dressings to be carried; it permits the collection of the wound discharges in some kind of receptacle and prevents the maceration of the skin; the pressure in the empyema cavity is more easily kept at a lower level than that in the bronchi and in the interior of the lung and because of this the expiratory effort can more easily help in the contraction and obliteration of the empyema cavity. A disadvantage of the method is that with all the various means of applying suction the patient must necessarily be confined to bed as long as the suction is maintained. A doubtful amount of suction can be maintained by means of a Politzer bag, as in the method described by Bryant. I believe, however, that the method is not very efficient, and after the first few minutes of its application the bag probably exercises none of the function for which it was intended; it is necessary to have the sucking device constantly active to overcome the leakage which occurs around the drainage apparatus.

The antiseptic treatment of empyema wounds has grown very much in favor. The principles and technic, as developed by Carrel and Dakin, are employed for this purpose. It is hoped to secure a complete sterilization of the empyema cavity with the object of secondarily closing the outer wound; the length of time necessary for complete cicatrization of the wound is thus very materially shortened. In actual practice this ideal result is not always accomplished because of the following reasons: in empyema complicated by broncho-pulmonary-cutaneous fistula the method is not applicable; it is very frequently impossible to secure complete sterilization, owing to the difficulties of the technic to be employed; when, apparently, sterilization is secured, closure of the outer wound by suture is not always successful, or a secondary collection of pus having accumulated within the thorax the wound reopens shortly and the entire curriculum must be gone through again.

The difficulties in securing complete sterilization are the real obstacles to the successful employment of an otherwise very valuable method. There are a number of reasons why it is frequently impossible to sterilize the cavity: (1) Very often there are sacculations to the cavity connecting with one another by comparatively small and not easily accessible channels; or there are several independent collections of pus situated at different locations within the thorax; if the antiseptic solution does not reach every part of the interior of the cavity the method is, of course, futile. (2) Small foci of infection can be located in one or many parts of the wall of the empyema cavity, and when liquefaction occurs the pus ruptures into the empyema cavity and reinfects the latter. These foci may be in the superficial parts of the pulmonary parenchyma and result from the original pneumonic condition, or they are in the parietes. The most important of the latter reside in the ends of the resected ribs: I referred above to the disadvantage of rib resection; the parts involved in the osteomyelitic process form a nidus from which the constant reinfection of the empyema cavity takes place. (3) At any portion of the wall of the cavity the progressive contraction of the latter often lends itself easily, from the formation of superfluous adhesions, to the production of small retention abscesses; sooner or later these rupture and reinfect the original cavity. All of these may lie dormant for relatively long periods of time and I believe that at least some of the "secondary empyemas" which make their appearance after the thoracotomy has apparently healed solidly are due to such causes.

In the instillation of Dakin's solution into the empyema cavity there are wide differences in practice among all of the men especially as to the amount of fluid to be employed. Some use a comparatively small amount—10 to 15 c.c.—others use relatively larger amounts; many use an arbitrarily chosen quantity—usually about 100 c.c.—or the quantity is determined by the length of time the fluid is allowed to run into the chest. Such practice is characterized by a certain timidity and lacks the precision which is a highly desirable factor. Inasmuch as it is very essential to secure an actual contact between antiseptic solution and the entire surface extent of the cavity to be sterilized in order to secure the actual sterilization, it is necessary in some way to employ the method with this object in view. Many employ a number of Carrel instillation tubes, which, being stiffened with wire, are made to reach all surfaces of the cavity; the fluid flowing inward is thus made to reach all surfaces; the amount of solution is, however, comparatively small; the contact of fluid and wall is only present for a few seconds, and thereafter the fluid settles in the bottom of the cavity and a relatively large part of the interior is not in contact with the solution.

I make use of a large tube for drainage, which is coupled with the suction apparatus. The tube leading from the chest to the collecting bottle is made to connect by a T-tube with the reservoir containing the Dakin solution. The total capacity of the empyema cavity is measured with water and noted. The amount of Dakin's solution which is instilled at two-hourly intervals is equal to a few cubic centimeters less than the measured capacity. At the appropriate time the suction is blocked off with a clamp and the Dakin solution is allowed to run in to the amount indicated. Inasmuch as the effect of the free chlorin liberated from the solution is only operative for a very few minutes, there is no necessity for allowing the solution to remain in the chest for any length of time and at the end of fifteen minutes the suction is reëstablished and the entire contents are evacuated from the thorax. The suction is allowed to continue until the next instillation. If desirable the procedure can be repeated at hourly, instead of two-hourly, intervals.

It seems to me that this method is most satisfactory for assuring an intimate contact of antiseptic solution and surface to be sterilized.

The large amount of fluid, employed as I have indicated, flows easily into the main cavity; it flows just as easily through any narrow communication into any subsidiary loculi or around any obstructing adhesions; it makes contact efficiently with smooth or distorted or irregular cavity walls and with that of any subsidiary cavities; it remains in contact for the full time for which the fluid is of any use.

The use of any method of irrigation is a new departure from the custom maintained up to the time of publication of the studies of Carrel and Dakin. One has always been taught that irrigation of any kind is dangerous when employed within the chest and from time to time serious consequences have been reported. The knowledge has, perhaps, been a deterrent to the use of Dakin's solution in some quarters and has encouraged the use of small quantities cautiously instilled in others. It is known that similar accidents follow the use of other intrathoracic procedures, especially puncture and aspiration of the chest. There have been no untoward effects or results in my experience with Dakin's solution. I realize, however, that a certain amount of danger exists, but I believe that the method ought to be persisted in because of its intrinsic value, especially since the actual danger of the irrigations is after all relatively and numerically very small.

The presence of a bronchopulmonary fistula of any magnitude makes the method impossible of application, owing to the "gassing" of the patient by the liberated chlorin gas. I remember several patients who showed a moderate amount of distress from this irritation, and if I had followed the usual practice I should have immediately abandoned the irrigations as part of the after-treatment. On subsequently repeating the irrigation I was surprised to note the absence of any irritative signs and thereafter the solution was tolerated very well. I remember in a number of other patients that signs of chlorin irritation were apparent at late periods of the postoperative course which were present on only one, or at most several, occasions in each patient, but which were not sufficient to deter us from continuing the use of Dakin's solution. The probabilities are that minute fistulæ were present which in some way were quickly closed, or which, because of their tortuosity or other mechanical obstruction, did not always permit any of the solution to enter the parenchyma of the lung. Perhaps the irritation of the chlorin was itself effective in closing the fistulæ because of the inflammatory swelling of the tissues making the sinus tract. At any rate if the initial trial of solution is followed by embarrassment the effect ought to be corroborated by a second more carefully carried out instillation before the irrigations are definitely abandoned.

There is a great deal of difficulty in making an accurate determination of the sterility of the cavity. The smear method is not at all reliable, not only because of the possibilities of error while looking through the smear, but because it is common knowledge that many colonies of bacteria will grow on media when no organisms are visible in the smear. Cultures are always necessary. The sterility of the outer wound is quite easily demonstrated; within the cavity it is not possible to reach all parts for specimens; and while seemingly all that are obtained are sterile, other foci may be present which harbor many organisms. It is quite true that an absolute sterility is not necessary for the secondary closure of the wound.

As soon as the sterility of the cavity is established with a reasonable degree of certainty the practice is to discontinue all forms of irrigation or other treatment. The immediate suture of the outer wound is perhaps not advisable, owing to the frequency with which the wound reopens to permit the discharge of retained pus. It is much better practice instead to simply cover the wound with a dry dressing and to permit the wound to heal by granulation. The outer wound closes very rapidly; a larger or smaller cavity—a pneumothorax—remains which, when truly sterile, does no harm; after a time the pneumothorax becomes absorbed and the cavity becomes obliterated. The pneumothorax shows no clinical evidences either subjectively or objectively. Permanent healing of the cavity must necessarily occur by complete obliteration. This probably occurs as a creeping adhesion of the adjoining parietal and visceral edge of the lining granulation membrane.

In order to obtain good results constant and persevering attention is needed in the postoperative period. The work of the Empyema Commission has shown the importance of maintaining the nourishment of empyema patients at as high a level as possible; special attention is necessary to the nitrogenous elements of the diet. This corresponds with our previous knowledge in regard to the feeding of patients afflicted with suppurating foci. The importance of not neglecting the primary condition to which the empyema is secondary cannot be overemphasized and the rule holds good both with the epidemic and with the ordinary cases. During the postoperative course the primary illness—especially the pneumonia—may continue, or, after it has apparently subsided, it may recrudesce. Other complications are numerous and in children these frequently take the form of intercurrent disease having no or little relation to the thoracic condition. The importance of all of this is readily appreciated when it is known that under ordinary circumstances approximately 20 per cent. of empyema patients die as a result of the primary illness, or of a recurrence of it, or of some other complication or intercurrent disease; under extraordinary conditions (epidemics) the percentage is considerably higher. The table of complications given in my 1915 communication is reproduced for the sake of emphasis.

TABLE OF COMPLICATIONS.

	Cases.	Deaths.
Pneumonia	23	19
Pneumonia and pleural effusion	2	2
Bronchial fistula	4	
Empyema on other side	2	2
Pulmonary edema	4	4
Bronchiectasis	1	
Cellulitis of chest wall	2	
Necrosis of resected rib	4	
Subcutaneous abscess at a distance from the empyema wound	9	
Brain abscess	2	2
Bacteremia	5	5
Tuberculosis of the resected rib	1	
Middle ear suppuration	14	2
Thrombosis of lateral sinus	1	1
Meningism	2	1
Cerebrospinal meningitis	1	1
Tuberculous meningitis	1	1
Acute endocarditis	1	1
Myocarditis	1	
Acute insufficiency in chronic valvular disease of the heart	1	1
Nephritis	4	2
Nephritis, pulmonary edema	1	1
Pyelitis	1	
Catheter infection in a tabetic	1	1
Pharyngeal diphtheria	1	
Measles	2	
Pertussis	1	
Scarlet fever	1	
Enterocolitis	2	2
Follicular tonsillitis	1	
Rickets	1	1
Marasmus	2	2
Subacromial bursitis	1	
Pott's disease of the spine	1	
Amyloid disease of the viscera	1	
Nevus of vocal chord; asphyxia	1	1
Acute mastoiditis	1	

The important complications listed by Stone,[7] Bliss,[5] and Phillips[9] (Fort Riley cases) include the following:

Pericarditis	5.9 per cent.
Large pleural effusion	4.8 "
Substernal pus pockets	3.3 "
Pulmonary abscess	3.0 "
Peritonitis	2.7 "
Endocarditis	1.2 "
Miliary tuberculosis	0.8 "
Meningitis	0.3 "
Pulmonary embolism	0.2 "

The important complications listed by Vaughan and Schnabel[10] (Camp Sevier cases) include pericarditis, urticaria, peritonitis and arthritis. Multiple complications were common. The complications noted by Stone, Bliss and Phillips[9] and by Vaughan and Schnabel[10] reflect more especially conditions associated with epidemic conditions.

In the postoperative period fever of one kind or another is a very common phenomenon. Most frequently it is due to any one, or more, of the complicating conditions just enumerated and the explanation of the fever is simple; occasionally the demonstration of the cause is difficult. Very commonly fever is due to the retention of pus within the wound; very commonly the amount of retained pus does not correspond, apparently, with the degree of fever but improvement in the drainage immediately results in the fall of the temperature. The retention of pus is sometimes located within the pulmonary parenchyma either in a definite focus of lung suppuration or within the confines of a bronchopulmonary fistula, from either one of which the escape of the purulent discharge is temporarily impeded.

A moderate grade of fever running along for some time is quite commonly caused by an osteomyelitis of the rib.

(Under the newer methods of treatment there has been a pronounced improvement in the results obtained with operations for empyema. Less frequently than heretofore the sinus in the chest fails to close within a reasonable length of time. Difficulties arise with the interpretation of the latter term, for a length of time which is "unreasonable" to one man is regarded with more or less indifference by another. Lilienthal[14] waits only a very short time after doing the primary intercostal incision—minor thoracotomy—before he proceeds to do his larger operation of major thoracotomy; he believes the secondary procedure necessary in a great many of the cases. Recently, Aschner, who is associated with Lilienthal, expressed the opinion* that the secondary major thoracotomy is not necessary as often as was first believed.) My own experience has led me to the opinion that minor thoracotomy is all that is necessary in the very great majority of the patients when none of the impeding factors spoken of below are present. In any case I am accustomed to wait a very long time before doing any secondary operation as long as I am sure that drainage is perfect and that there are no mechanical factors interfering with the cicatrization of the wound. I was very much influenced toward this opinion by the course of the healing of the wound in the following case:

A middle-aged man was operated upon by rib resection for a postpneumonic empyema; the sinus persisted for fifteen months, at the end of which time I saw the man for the first time. A small opening was present in the chest which discharged some foul pus; the roentgen ray showed a homogeneous shadow covering the whole of the involved side. A radical operation having been determined upon the chest was opened widely through an intercostal space and the incision was prolonged upward, posteriorly, parallel to the spine, with division of the ribs (Torek). An enormous cavity was disclosed reaching from the very top to the very bottom of the thorax and fully as wide as the depth of the chest. Owing to the presence of a large amount of very foul pus the intention to proceed with an extensive thoracoplasty (Schede) was temporarily abandoned until the suppuration could be controlled. The wound was left wide open and was dressed after the Carrel-Dakin technic. At the end of six months the outer wound had contracted and closed down to a very narrow slit. I had hoped from the way the wound had been healing that any further operation would be unnecessary; but at that time six months seemed "unreasonably" long and I determined to proceed with my original intention. On reopening the wound I was astounded to see that the original huge cavity had contracted down to a narrow gutter barely a finger's breath in width. I am quite sure that if I had waited but a little while longer, the entire wound would have closed spontaneously.*

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* In a personal communication this opinion was confirmed by Lilienthal.

There are a number of factors which interfere with the closure of the thoracic sinus after operations for empyema. Practically all of these functionate by constantly reinfecting the cavity which is to cicatrize, and many of them are those which interfere with the proper sterilization of the wound with Dakin's solution. Over some of these we have almost perfect control, as, for example, a badly carried out drainage or an osteomyelitis of the resected rib. Over others we have only partial control: such would be those empyemata which are not simple cavities but in which the main cavity is complicated by subsidiary loculi; the drainage of the latter is at best imperfect.

The more I see of empyemata the more I am convinced that the greatest obstacle to healing is the presence of a bronchopulmonary fistula: over this impediment we have no control at all. The fistula may be so small as to readily escape demonstration. I feel convinced that bronchopulmonary fistula is a very frequent complication of empyema even in cases in which no disturbance in the healing is apparent and in which, of course, no inkling of its presence can be furnished. This should not appear extraordinary in view of the opinion that many, if not all, of the empyemata complicating pneumonia result from the superficial abscesses (Rosenbach)[13] which rupture into the pleural cavity. The importance of bronchopulmonary fistula in causing chronic sinuses seems to be corroborated by the further observation that almost all of the chronic sinuses follow the postpneumonic type of empyema. My experiences seem increasingly to show that as a cause for chronic empyema sinuses, bronchopulmonary fistula holds first place.

In previous years much has been said about rigid cavities as efficient causes for the failure of closure of the thoracic sinuses. I do not believe, however, that the rigidity of the empyema walls—and here, of course, I speak especially of the visceral layer—is a primary phenomenon. I have the impression that it is distinctly a secondary process, owing its presence to any one of the causes mentioned in this communication, which functionate as impedimenta to the healing by constantly reinfecting the cavity. The constant reinfection is conducive to an overproduction of scar tissue in the granulation membrane lining the cavity, and the superabundance, by its very massiveness, lends the unyielding qualities to the visceral surface. A vicious circle is thus formed, so that frequently a pneumolysis of some sort is necessary to permit, or to aid in permitting more rapidly, the expansion of the lung. But in very many cases the efficient removal, operative or otherwise, of the essential primary cause is followed by a progressive yielding of the membrane and an obliteration of the cavity. It is significant that with increased knowledge much less has been said in the last few years of rigid cavities as causes for chronic empyema sinuses.

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* Private records.

Recurrences of empyema are fairly common. I should rather term this an incomplete healing of the original empyema. The essential cause for this accident is again an incomplete sterilization, or a reinfection, of the cavity; and the causes for the latter include: (1) Incomplete obliteration of the original cavity; (2) a bronchial fistula; (3) rib sequestra; (4) islands of dormant bacteria in the walls of the empyema cavity; and (5) the retention of foreign bodies.

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10. Vaughan and Schnabel: Arch. Int. Med., 1918, xxii, 440.
11. Wilensky: Surg., Gynec. and Obst., 1915, xx, 501, 647.
12. Whipple: Surg., Gynec. and Obst., 1918, xxvi, 29.
13. Rosenbach: Nothnagel, Spez. Path. u. Therap., Wien, 1914, xiv, 1.
14. Lilienthal: Ann. Surg., July, 1919, and September, 1917.

SUBSTERNAL GOITER, WITH PRESSURE SYMPTOMS.[1]

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Summary. Female, aged sixty-four years, suffering from goiter, with symptoms of hyperthyroidism. Enlargement of the thyroid

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gland above the sternum very marked. The tumor also extended below the sternum and by pressure on the right phrenic nerve produced paralysis of the right side of the diaphragm and by pressure on the recurrent laryngeal nerve produced partial paralysis of the right vocal cord; it also displaced the heart toward the right side, producing a loud systolic murmur, with its intensity at the apex and a marked myocardial insufficiency.

Treatment. Roentgen ray, rest and medication.

Result. A fairly satisfactory recovery, the paralysis of the right diaphragm and right vocal cord remaining.

April 10, 1917. *Personal History.* Thirty-three years ago the thyroid gland began to enlarge and it has been enlarged ever since, but the patient has never had any symptoms referable to this condition. In 1916 I found pus in her urine, which readily yielded to treatment with urotropin and benzoate of soda. In the winter of 1917 pus was again found in her urine and disappeared under the same treatment.

December 1. The patient's present illness began during the summer of 1917, while at her summer home at the seashore. During August of this year she suffered from mental depression and shortness of breath. Early in September she consulted a physician, who found that she had a well-marked cardiac murmur and that her urine contained pus.

About the middle of October she was taken to New York and placed under the care of a physician, where she remained until her return to Cincinnati on November 29, 1917. Her physician in New York reported that she had dyspnea on exertion, a well-marked systolic heart murmur, a blood-pressure of 148–74, a sterile blood culture and a negative Wassermann. On October 22 a blood examination showed hemoglobin 85 per cent. red blood cells 5,400,000, white blood cells 5000, polymorphonuclears 41, lymphocytes 54, eosinophiles 5. The urine examined on October 22 and November 12 contained no pus, and except for a very faint trace of albumin was negative. The patient was kept off her feet and in bed the greater part of the time she was in New York, and during this time she improved very materially. The cardiac dulness decreased.

On sending the patient to Cincinnati her physician wrote: "I feel that Mrs. Blank has for a basis of her cardiac changes a mild hyperthyroidism. She has had from time to time, in addition to the goiter, the following clinical evidence to substantiate this view: (1) Instability of pulse and a marked tendency to develop tachycardia; (2) flushing; (3) tremors."

November 30 I saw the patient at her home, twenty-four hours after her arrival from New York. She had been in bed during that time; she had symptoms of mild hyperthyroidism, a loud systolic murmur was heard most distinctly near the apex of the heart, which was transmitted into the axillary region, and was also heard very